TABLE I-continued

Sample	Shear Strength, Psi
Control 2	570 (310)
Control 3	1010 (420)
Control 4	700 (515)
Control 5	1170 (320)
Control 6	970 (33)
Example 1	1420 (165)

The values in parentheses were the standard deviations. Three specimens of each sample were tested. The value obtained for Control 1, the mesh bonded steel rod, is considered to be approximate maximum obtainable with the cement tested. In Control 1, the cement itself failed, rather than the interface.

As the foregoing experiment indicates, the addition of a thin, adherent coating of a siliceous material (in this case, silica) to the surface of crystalline alumina enables one to obtain a strong adhesive bond between crystalline alumina and adhesives. In the preferred way of practising the invention, a silane coupling agent is used to enhance the bond between the siliceous coating and the adhesive. The type of silane that is used is dependent upon the nature of the adhesive, as is known in the art.

For instance, when an acrylic resin is used as the adhesive (or, indeed, any adhesive that cures by polymerization of an ethylenic double bond), the silane (e.g., A-174) will ordinarily contain an ethylenic double bond that interacts with the resin. If an epoxy adhesive is used, the silane (e.g., A-1100) will usually contain an amino group, preferably a primary amino group, which group will interact with the polymerizing epoxy resin. The principles of selecting a coupling agent to enhance the bond between a siliceous material and an adhesive are known, and the known principles are applicable here.

The invention has been described most particularly with respect to the use of crystalline alpha-alumina (sapphire) as the material from which orthdontic brackets are made. However, other crystalline alumina materials can be used in the invention. The limiting requirements for an orthodontic bracket are adequate modulus of rupture (i.e., greater than about 35,000 psi, which is the yield strength of the steel that is currently used for most orthodontic brackets), and sufficient transparency that the natural tooth color can be seen through the bracket. Other crystalline alumina materials that can be used include yttrium aluminum garnet, magnesium aluminum spinel, and alpha-alumina in which a small percentage of the aluminum atoms has been replaced with other elements to impart color and/or fluorescence to the crystal. For instance, fluorescence can be imparted to the crystal by the addition of small amounts (e.g., less than 1 mole percent) of terbium oxide or cerium oxide to the aluminum oxide.

The invention is also not limited to orthodontic brackets. It is applicable to any composite wherein a crystalline alumina article is to be bonded to another article.

The siliceous coating on the alumina is preferably silica, but can also be other siliceous materials such as glasses that contain significant amounts, usually at least 50 mole percent, of silica. Other materials that can be present in the siliceous material include alkali metal oxides, alkaline earth metal oxides, boron oxide, lead oxide, alumina, rare earth metal oxides (to impart fluorescence), and the like.

What is claimed:

1. A composite comprising a crystalline alumina article adhesively bonded to a substrate, wherein at least a portion of the surface of said article that is adhesively bonded to said substrate comprises crystalline alumina having a thin adherent coating of a siliceous material, wherein said siliceous material consists essentially of silica or a glass containing at least 50 mol percent silica.

2. The composite of claim 1 wherein the adhesive bond between said coating of a siliceous material and the adhesive bonding said article to said substrate is enhanced by a silane coupling agent.

3. The composite of claim 1 or 2 wherein said crystalline alumina is crystalline alpha-alumina.

4. The composite of claim 1 or 2 wherein said siliceous material is silica.

5. The composite of claim 3 wherein said siliceous material is silica.

6. The composite of claim 1 or 2 wherein said article is an orthodontic bracket comprising a base member including a tooth contacting surface and a body member extending from said base member, said body member including walls defining an archwire groove.

7. The composite of claim 3 wherein said article is an orthodontic bracket comprising a base member including a tooth contacting surface and a body member extending from said base member, said body member including walls defining an archwire groove.

8. The composite of claim 2 wherein said article is an orthodontic bracket comprising a base member including a tooth contacting surface and a body member extending from said base member, said body member including walls defining an archwire groove.

9. The composite of claim 8 wherein said composite comprises an orthodontic bracket.

10. The composite of claim 2 wherein the adhesive is an epoxy resin and the silane coupling agent contains an amino group.

11. A method of producing a composite which comprises the steps of coating at least a portion of the surface of a crystalline alumina article with a thin adherent coating of a siliceous material, and then bonding said article to a substrate by adhesively bonding said surface having the siliceous coating to the substrate using an adhesive that has an adhesive affinity for said siliceous coating.

12. The method of claim 11 wherein said siliceous material is silica.

13. The method of claim 11 or 12 wherein the crystalline alumina is crystalline alpha-alumina.

14. The method of claim 11 or 12 wherein the adhesive bond between said adhesive and said siliceous coating is enhanced by the use of a silane coupling agent.

15. The method of claim 14 wherein the adhesive is an acrylic material and the silane coupling agent contains ethylenic unsaturation.

16. The method of claim 11 or 12 wherein said article is an orthodontic bracket comprising a base member including a tooth contacting surface and a body member extending from said base member, said body member including walls defining an archwire groove.

17. The method of claim 13 wherein said article is an orthodontic bracket comprising a base member including a tooth contacting surface and a body member extending from said base member, said body member including walls defining an archwire groove.

18. The method of claim 14 wherein said article is an orthodontic bracket comprising a base member includ-